INSTRUCTION HANDBOOK FOR THE MELLES GRIOT NANOPOSITIONING MODULAR SYSTEM

NANOTRAK CONTROL MODULE

COVERING PRODUCTS OF NUMBER 17MNA001

MELLES GRIOT

Cambridge England

MG Ltd part number HA0086 issue 1

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Revision History

The following table shows the revision history of this handbook:

Issue Number	Date	Summary of amendments
1	14-Aug-98	

Safety Information

Read this information carefully before installing or using the equipment.

This unit complies with the European Standard EN61010 as a POLLUTION DEGREE I, INSTALLATION CATEGORY II piece of equipment.

The Equipment, as described herein, is designed for use by personnel properly trained in the use and handling of mains powered electrical equipment. Only personnel trained in the servicing and maintenance of this equipment should remove its covers or attempt any repairs or adjustments.

For the continuing safety of the operators of this equipment and the protection of the equipment itself the operator should take note of the **CAUTIONS** and **WARNINGS** throughout this handbook and, where visible, on the product itself.

The **CAUTION** statement is used to alert the user to the correct method of operating the equipment without injury or damage being caused.

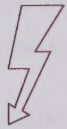
The **WARNING** statement alerts the user to areas of the product that may be hazardous to health.

Safety symbols

The following safety symbols may be used on the equipment:

Read the operating instructions before use

Connection to earth



High voltages present

EARTH point

Identifying unsafe equipment

Whenever it is suspected that the safety of the product has been impaired, it is recommended that an appropriate label, recognised by your company, be attached and that the unit be removed to a place of repair.

Electrical connections

The module should be connected to no electrical equipment, other than the purpose made rack and accessories supplied by Melles Griot.

Internal fuses

The following fuses are used on the circuit board of the module. They are not user replaceable.

Fuse	Rating/A	Type
F1	0.5	T NanoFuse, antisurge
F2	0.5	T NanoFuse, antisurge
F3	1	T NanoFuse, antisurge

Environmental conditions

The unit has been designed to operate normally under the following environmental conditions:

Location	Indoor use only
Maximum altitude	2000 m
Temperature range	5°C to 40°C
Maximum humidity	Less than 75%

CAUTION➔ **CARE SHOULD BE TAKEN TO ENSURE THAT PROPER AIRFLOW TO THE UNIT IS MAINTAINED.**

WARNING➔ **OPERATION OUTSIDE THE ABOVE LIMITS MAY ADVERSELY AFFECT OPERATOR SAFETY.**

Output voltage

The Drive Output is rated as follows:

Nominal maximum	10 V

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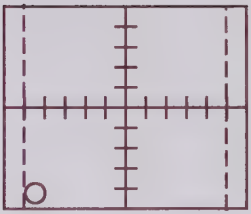
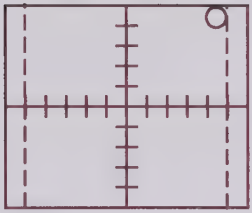


Fibre at minimum position on horizontal and vertical axes



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Note that the regions to the extreme left and right of the display, outside the dotted lines shown on the diagram above, are not used. **10**

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How to use this handbook

Before using the equipment, please read carefully the Safety Information on page i.

The handbook begins with a description of the NanoTrak Control Module including its front panel controls and indicators. It explains the principles behind how the NanoTrak aligns optical fibres. It describes operation from the front panel, and then goes on to describe the more advanced features possible through programmed operation from the Controller PC.

To use the NanoTrak Control module, you need a Main Rack, a Controller, two Piezoelectric Control Modules, a piezo-actuated stage and software drivers for the language you are using. Please refer to the instruction handbooks for these complementary products, as tabulated below.

In particular, the handbook for the *Main Rack and Controller* covers how to install the module into the rack and how to configure the whole system from software using the configuration program MG17_Config.

Table 1: Complementary products and instruction handbooks for the Melles Griot Nanopositioning modular control system. Note that new products may be added to this list.

Product Name	**Product Number(s)**	**Part number of Instruction Handbook**
Main rack and controller	17MMR001 17MRC001 17MRC002	HA0088
NanoStep Motor Control Module	17MST001	HA0085
Piezoelectric Control Module	17MPZ001	HA0087
NanoTrak Control Module	17MNA001	HA0086
LabVIEW drivers	17LVD002	HA0091
Visual Basic drivers	17VBD002	HA0092
Dynamic Link Libraries		HA0093
NanoMax-HS 6 axis stage	17MAX600 series	HA0083
NanoMax-HS 3 axis stage	17MAX300 series	HA0094
NanoStep Linear stages	17NST101 series	HA0031
NanoRotator	17AMR101	HA0040

Technical Support

If you cannot find the answers you need in these handbooks, please contact us for technical support either through your local representative, or at the address below:

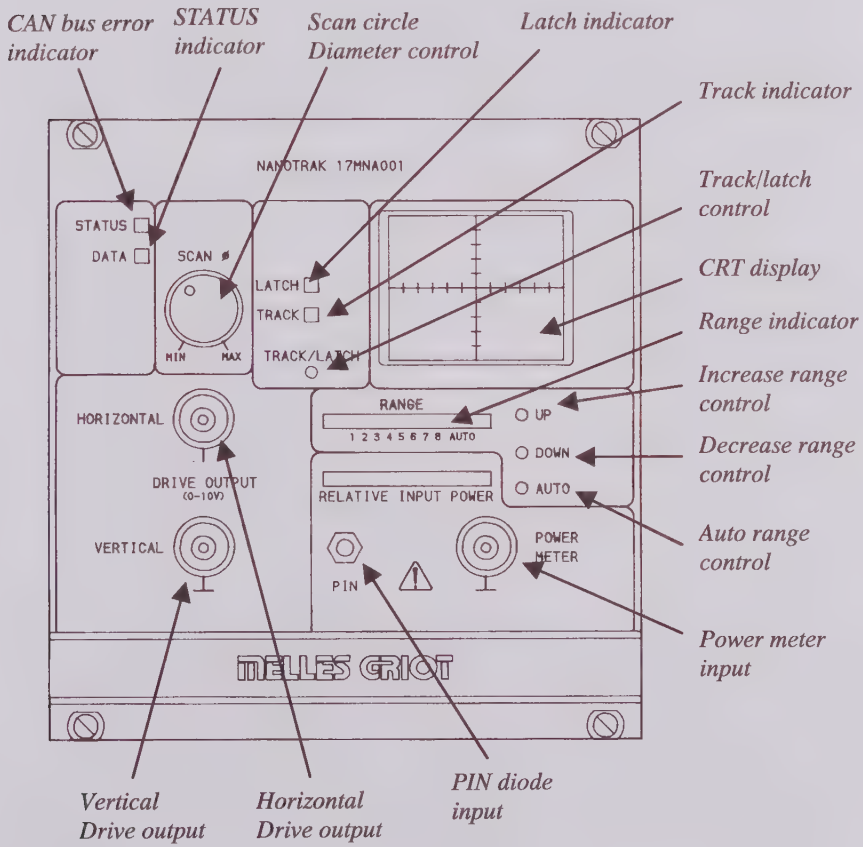
MELLES GRIOT LIMTED
1 SAINT THOMAS PLACE
CAMBRIDGESHIRE BUSINESS PARK
ELY
CAMBS CB7 4EX
TEL + 44 [0] 1353 654500
FAX + 44 [0] 1353 654555

It is always helpful to have detailed and accurate information about any problem you encounter.

We welcome your comments or suggestions about any aspect of the equipment and instruction handbooks.

Description of front panel

The design of the NanoTrak Control module is such that basic operation may be carried out from the front panel, whereas more advanced features are available through programmed operation from the Controller.



CAN bus error indicator shows an error in communication between the module and the Controller. A yellow light shows that the module can listen but not talk to

the Controller. A red light shows that it can neither listen nor talk. When the light is off, there is no error.

Status indicator A green light shows that the Controller is addressing the module

Scan circle diameter control is used to adjust the diameter of the scan circle, as seen on the CRT display.

Latch indicator indicates that the NanoTrak is in latch mode, with the scan circle shrunk to a dot and held in a constant position.

Track indicator shows that the NanoTrak is tracking the position of maximum power.

Track/latch control, used to switch between latch and track modes.

CRT display of the horizontal and vertical drive output voltages, corresponding therefore to the horizontal and vertical position of the piezo-actuated stage driven by the NanoTrak.

Range indicator displays the current range of the internal power meter.

Increase range control, push button control used to increase the range of the internal power meter.

Decrease range control, push button control used to decrease the range of the internal power meter.

Auto range control, push button control used to switch between auto and manual ranging.

Power meter input (BNC connector) used to receive a signal of optical power from an external power meter.

PIN diode (SMB connector) used to receive a signal from a PIN diode, as incorporated in the detector heads supplied with the module.

Detector heads and cables

The unit is supplied with two detectors heads. The visible (silicon) detector head, part number 17NTA001, bears a white label, whereas the near-infrared (germanium) detector head, part number 17NTA003, bears a red label.

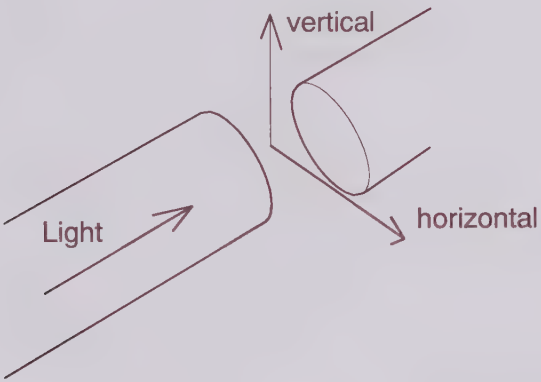
Each detector head incorporates a PIN (p-type/intrinsic/n-type) diode and a cross-polarized attenuator.

The detector head is connected to the NanoTrak using the SMB-terminated cable supplied.

Two 0.5m long BNC-terminated cables are supplied for connection of the NanoTrak to the Piezoelectric Control Modules.

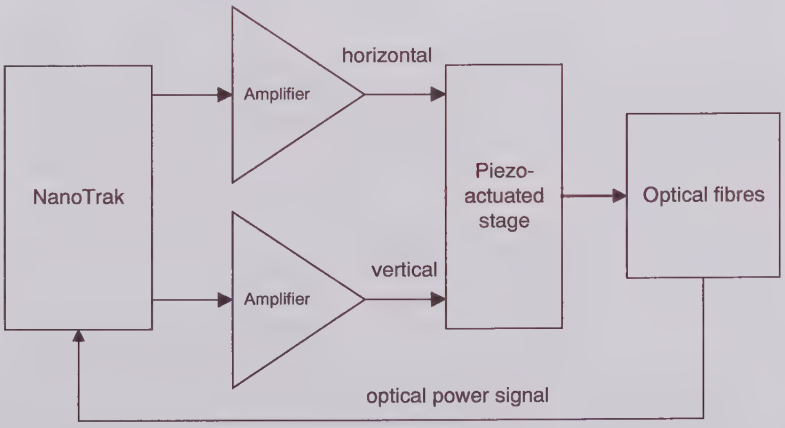
The NanoTrak control loop

The NanoTrak is used to align two optical fibres:



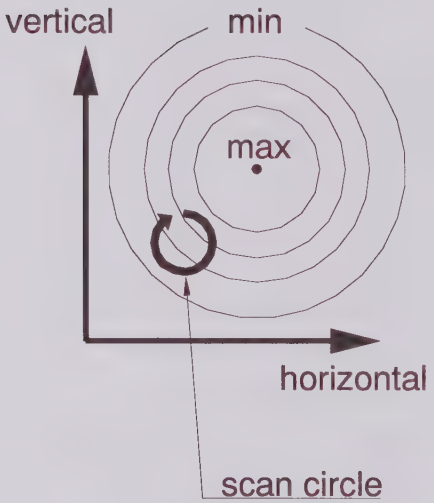
In many applications, a waveguide or similar device replaces one of the fibres in the diagram. This makes no difference to the principle of operation, however.

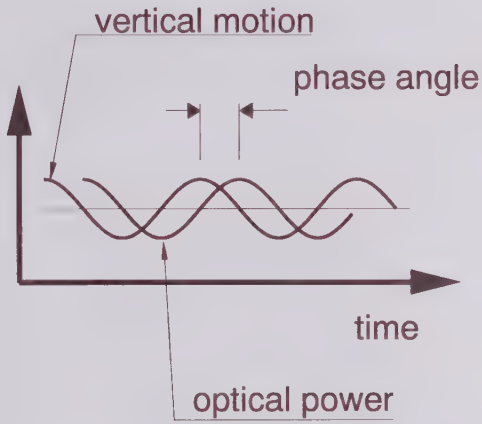
One of these fibres is mounted on a piezo-actuated stage that moves the fibre in the horizontal and vertical axes. The NanoTrak must adjust the position until the power transmitted between the fibres is maximized. Below is a block diagram of the NanoTrak control loop:



How the NanoTrak maximizes the optical power

The optical power transmission can be plotted as a function of the horizontal and vertical positions of the moving fibre, as shown on the contour graph below.



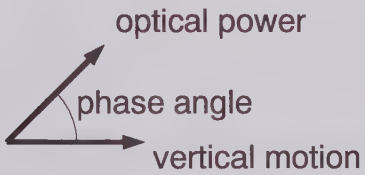


By detecting the local gradient of power, the NanoTrak can adjust the position until the power is maximized and the gradient becomes zero.

We could make an analogy by saying that the contours represent a mountain and that the NanoTrak must guide the fibre to the summit.

To detect the gradient, it is necessary for the NanoTrak to scan the fibre. The scan motion chosen is circular.

When we consider this motion superimposed on the contour map above, we see that the optical power will also vary sinusoidally with time, but with a phase that depends on the direction of the local gradient. The phase can be measured as an angle, relative to the horizontal sinusoidal motion, and represented as an arrow. This arrow points in the direction of maximum power:

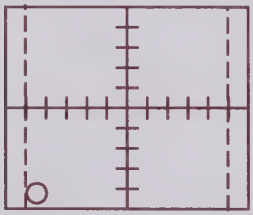


By detecting the phase of the optical power signal, the NanoTrak directs the fibre to the maximum.

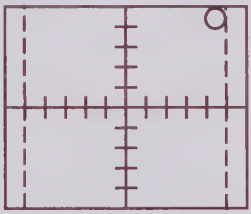
Once the NanoTrak has found the maximum, it locks on to it. Even if one of the fibres is moved slightly, the NanoTrak corrects for the movement to maintain the maximum power. This is called *tracking*.

The CRT display

The CRT (Cathode Ray Tube) of the NanoTrak is a graphical display of the horizontal and vertical drive outputs, and therefore of the position of the fibre. The circular scanning motion is shown on the display:



Fibre at minimum position on horizontal and vertical axes



Fibre at maximum position on horizontal and vertical axes

Note that the regions to the extreme left and right of the display, outside the dotted lines shown on the diagram above, are not used.

Circle size and automatic gain control

The NanoTrak system is a control loop and as such can be tuned to optimize the speed of response and stability.

There are two parameters that can be adjusted: circle size and loop gain. The circle size is normally adjusted from the front panel, however automatic adjustment can also be configured from the Controller. The loop gain is normally adjusted automatically, but fixed settings can be configured from the Controller.

Latch, Track and Tracking modes

The purpose of the latch is to hold the drive outputs at constant position. With the latch released, the NanoTrak is in track mode. However, tracking will only occur one a certain threshold of input power has been reached, sufficient for the NanoTrak to seek the maximum.

The three modes of the NanoTrak can be summarized as follows:

Modes of the NanoTrak:

Mode	Description	Latch indicator	Track indicator
Latch	Drive outputs held in constant position	ON	OFF
Track mode, not yet tracking	The drive outputs return to default settings of centre travel, awaiting input power threshold to be exceeded	OFF	OFF
Track mode and tracking	The drive outputs seek and maintain maximum power settings	OFF	ON

Setting up

Setting up the NanoTrak with the Stage and Optical Fibres

A typical NanoTrak set up using a NanoMax flexure stage is illustrated on the next page.

Step 1. Fit the NanoTrak Control Module and the two Piezoelectric Control Modules into the Main Rack (see *Instruction Handbook for the Main Rack and Controller*).

Step 2. Using the two BNC-terminated cables, connect the Vertical Drive Output of the NanoTrak module to the SUM External Control Input of one of the Piezoelectric Control Modules. Connect the Horizontal Drive Output of the NanoTrak Control module to the SUM External Control Input of the other Piezoelectric Control Module.

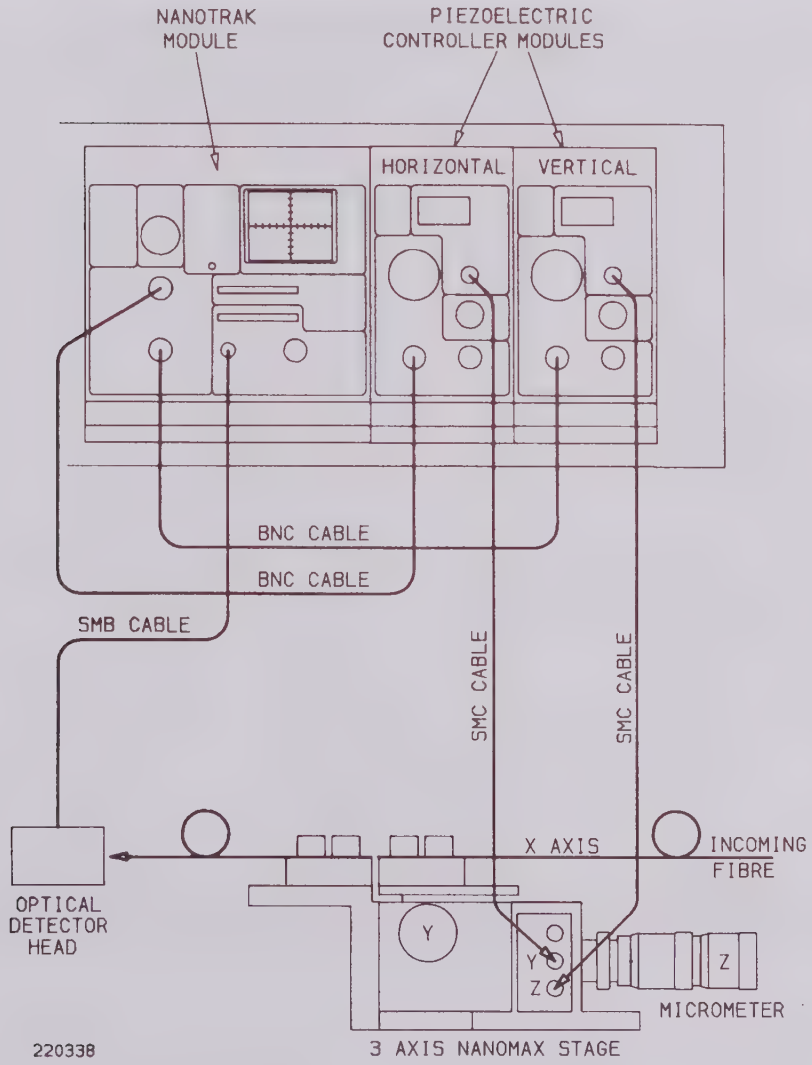
Step 3. Set the Manual control knobs on the two Piezoelectric Control Modules to zero.

Step 4. Connect the SMC-terminated cables from the Piezoelectric Control Modules to the inputs of the stage corresponding to horizontal and vertical motion. In the illustration, this corresponds to the Y and Z axes. However, if the NanoMax stage were used in a left-handed configuration, we would use the X and Z axes.

Step 5. Set up the optical fibres on the flexure stage, using a V-groove holder or similar, such that the light can be transmitted between them. The incoming fibre carries light from a source such as a focussed HeNe laser or pigtailed laser diode. Ensure the fibre ends are clean and well cleaved.

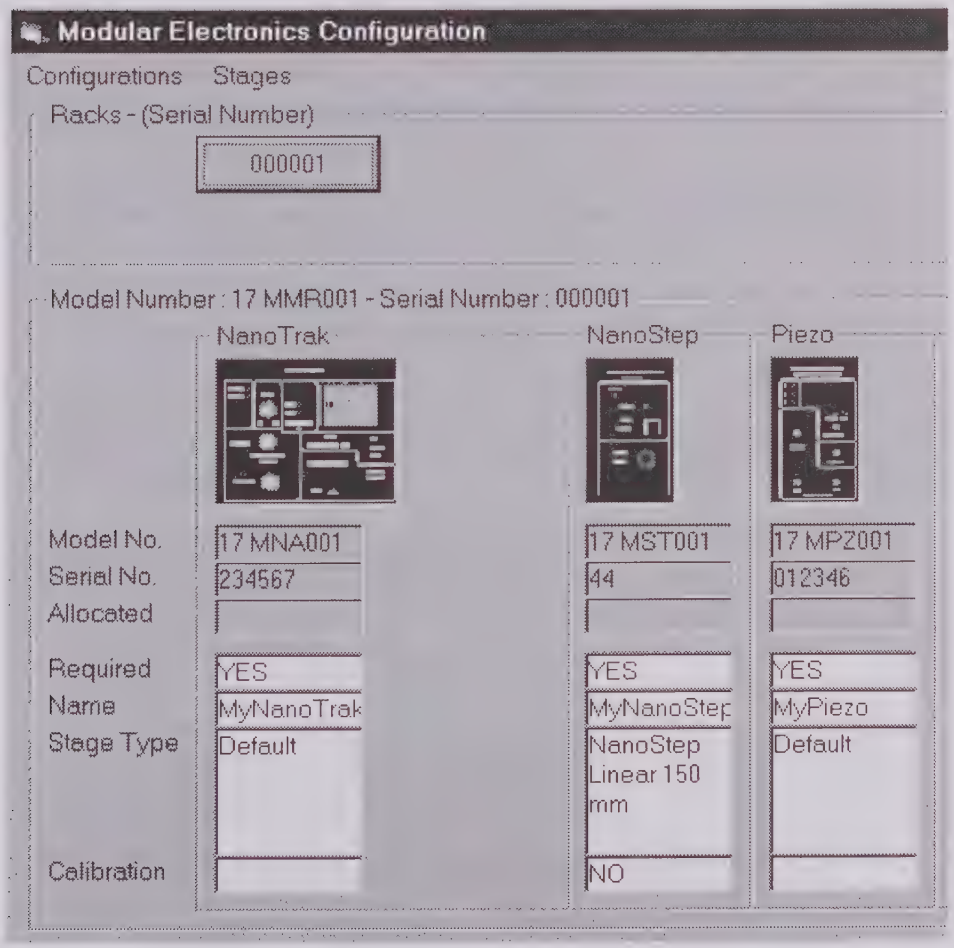
Step 6. The outgoing fibre is fed into the detector head. Select the type of detector (infra-red or visible) according to the wavelength of the light. Move the attenuator lever on the detector head toward the wide end of the ramp-shaped label.

Step 7. Using the SMB-terminated cable, connect the detector head to the PIN input of the NanoTrak.



Configuring the Controller

The configuration program MG17_Config (illustrated below) enables you to give a name to the module that can later be used as a handle in programming. If you do not require programmed operation, you can skip this section. See the instruction handbook for the *Main Rack and Controller* for a general description of MG17_Config.



To create a configuration for the NanoTrak module and other modules you wish to control:

Step 1. Run MG17_Config, to be found in the folder MellesGriot\MelHost\Config.

Step 2. Click (left-hand mouse button) on the icon of a module. The green STATUS light on the panel of the module flashes once as an aid to identification.

Step 3. If desired, drag the module icon into the slot on the screen that corresponds to the position of the real module in the real rack (this will make it easier to identify the module).

Step 4. Click (left-hand mouse button) on the Required field for the module. Select YES if you want to use this module.

Step 5. In the Name field, type a meaningful name of your choice. Later, you will use this name as a handle to the module when programming.

Step 6. Repeat 2 to 5 for each module you wish to configure.

Step 7. From the Configurations menu (top left-hand corner of screen), save the configuration you have created using a meaningful name of your choice. You may use this name later in the initialization part of a program you create.

Note that the Stage Type field is not used in the case of this module. It always shows Default.

Operation from the front panel

General approach

To learn how to use the NanoTrak, the following general approach is suggested.

Step 1. Make sure that the fibres can be aligned manually using the micrometers and that the expected level of power can be transmitted between them. For this step, set the NanoTrak to Latch and the range control to Auto. Observe the bar graphs on the front of the NanoTrak for an indication of power.

Step 2. Familiarize yourself with NanoTrak operation from the front panel of the module.

Step 3. Attempt programmed operation from the Controller PC only when you have completed these first two steps.

To align the fibres using the NanoTrak

Step 1. Set the scan circle diameter control to approximately mid-position.

Step 2. If the NanoTrak is in Track mode, set to latch.

Step 3. Double click the Latch/Track button. This sends the circle to the centre of the display.

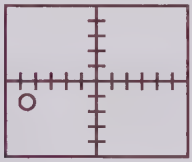
Step 4. Set the range control to Auto.

Step 5. Adjust the micrometers so that the fibres are spaced well apart, with zero power transmission between them. (Alternatively, switch off or obscure the optical power source). Make a note of the bar graph displays of relative power input and range. Since the optical source has been removed, you are seeing only background noise.

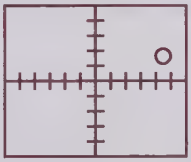
Step 6. Use the micrometers to bring the fibre tips together, until the bar graphs show a significant increase indicating that the power has risen above the background level.

Step 7. Switch from Latch to Track mode. The green Track light illuminates and the circle moves towards the position of maximum power.

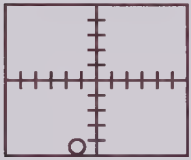
Step 8. If the circle reaches the edge of the display, this means that the piezo actuators cannot move far enough to reach the position of maximum power. The horizontal and vertical micrometers should be adjusted, as shown below, to bring the circle away from the edge of the screen.



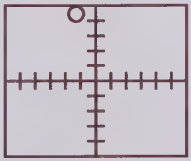
Decrease horizontal micrometer



Increase horizontal micrometer



Decrease vertical micrometer



Increase vertical micrometer

Step 9. If the circle tends to drift, increase the scan circle diameter.

Step 10. If the circle tends to oscillate, decrease the scan circle diameter.

The NanoTrak has now positioned the fibre to give the maximum optical power transmission.

Use with an external power meter

Power meters are available that give greater sensitivity and accuracy than the power meter internal to the NanoTrak. Such power meters can be connected to the power meter input (BNC connector) of the NanoTrak. The input defaults to a range of 1 V, although this can be changed to 2 or 10 V from the Controller PC. The front panel range buttons (UP, DOWN and AUTO) have no effect on the power meter input. To make sure noise does not enter the system, disconnect any detector from the PIN input and set the range to maximum.

The external power meter must give a true analog output that does not introduce any phase shift into the system. Some power meters, for example, give a smoothed output only suitable for driving a chart recorder.

Use of two NanoTraks in the same system

If the optical fibre on page 11 were cleaved in two places, two NanoTraks and two piezo-flexure stages could be used to align the 2 fibre couplings simultaneously. The NanoTraks must be set to generate scan circles at different frequencies. This is done by programmed operation from the Controller PC.

Programmed operation from the Controller

General approach

Programmed operation of the NanoTrak Control Module allows a wider range of functions to be used than operation from the front panel alone. You can also control other modules such as the NanoStep stepper motor control module in conjunction with the NanoTrak.

Whether you are programming the NanoTrak in LabVIEW, Visual Basic or another language, the general approach is the same. A typical application contains the following main steps:

Step 1. Load the configuration and get handles for the modules you wish to control. The handles are used as inputs to subsequent functions. The handles are user-chosen names as defined in MG17_Config (see page 13).

Step 2. Operate the modules, according to the functions listed below.

Step 3. Release the handles, to let the server know you have finished using them. The modules are then free to be used by another application.

The first and last steps are similar for all types of control module, including the NanoTrak Control Module. More details can be found in the software handbooks (see page 4).

The functions used in ***Step 2*** are now described in more detail:

Functions of the NanoTrak

The following functions of the NanoTrak have been implemented in LabVIEW and Visual Basic. In each language, you will find functions of similar names.

Each function is used to control a single NanoTrak. Where a Get function appears in brackets next to a Set function, the Get simply returns the parameters set.

More detailed information on these functions and other lower level functions can be found in the software manuals.

Non-volatile settings (retained on switching equipment off and on again) are marked [NV].

Get absolute power

Returns a value of optical power input in mW, based on a standard detector head, on the basis of the current range and relative input power.

Get relative power

Get the relative input power, a real number proportional to the front panel bar graph display.

Is it tracking

Returns 1 if the NanoTrak is tracking, 0 otherwise. If the NanoTrak is tracking the green tracking LED on the front panel illuminates. This occurs when the NanoTrak is in tracking mode and a certain input power threshold is exceeded.

Set frequency (Get frequency) [NV]

Set the scanning frequency, the number of circular scans per second. The factory setting is normally 42 Hz. Different settings allow more than one NanoTrak to be used in the same system.

Set phase offset (Get phase offset) [NV]

The phase offset applied to the input signal can be used to correct for phase lags introduced by external power meters.

Set circle diameter (Get circle diameter)

Sets the circle diameter, measured on a scale such that 10 units is the width and height of the screen. If, for example, the NanoTrak is driving a 20 micron actuator, a circle diameter of 1 unit will result in a real diameter of 2 microns. The function is also used to enable or disable the front panel scan circle diameter control knob and to enable or disable automatic circle size control.

Set circle position (Get circle position)

Moves the centre of the circle to given (x, y) co-ordinates, measured on a scale such that 10 units is the width and height of the screen. If, for example, the NanoTrak is driving a 20 micron actuator, one unit corresponds to a displacement of 2 microns.

Set latch or track mode (Get latch or track mode)

Choose between latch and track mode. The latch holds the circle at the current position and minimizes its diameter. In track mode, the circle attempts to find the position of maximum optical power.

Set range (Get range)

Sets the range of the internal power meter, an integer as indicated by the front panel bar graph display. The function is also used to set the internal power meter to automatic ranging.

Question and Answers

Question. Although the green TRACK light is on, the circle appears to wander across the display screen.

Answer.

1. Try increasing the size of the scan circle diameter.
2. Check the connections (see page 11). Check, using a dial gauge, that the stage moves in the horizontal and vertical axes (perpendicular to the fibre axis) when the manual control knobs on the Piezoelectric Control Modules are adjusted.
3. An important point is that the TRACK light is activated simply by an optical power threshold. If the power meter is set to a range that is too sensitive, it can be activated by noise. Increase the range, or adjust the micrometers to increase the optical power.

Question. Given the answer 3 above, how can I verify that the NanoTrak is really tracking?

Answer. If you make a small adjustment to one of the Micrometers, the circle will move slightly as the NanoTrak adjusts its drive outputs to track the maximum.

Question. Does the circle have to be precisely in the centre of the display?

Answer. No, the NanoTrak can track correctly as long as the circle is not at the edge of the display.

Question. The tracking only works over a very limited range of motion.

Answer. Check that the Manual control knobs on the Piezoelectric Control Modules are set to zero.

Question. The optical power transmitted from fibre to fibre is much less than I expected.

Answer. Check that the ends of the fibres are well cleaved and clean.

Specifications

Detector heads

Sensitivity, Visible head 0.164 A/W at 633 nm

Sensitivity, Infra-red head 0.154 A/W at 1550 nm

0.100 A/W at 1300 nm

Optical Power Input

PIN diode input with detector sensitivity of 0.164 A/W:

Range	**Full scale deflection**
1	200 pW
2	2 nW
3	20 nW
4	200 nW
5	2 μW
6	20 μW
7	200 μW
8	2 mW

BNC power meter input:

Range 1 (default)	0 to 1V
Range 2	0 to 2 V
Range 3	0 to 10 V

Tracking:

Scan frequency 20 to 250 Hz (default 42 Hz).

Drive outputs: 0 to 10 V

Dimensions: 24 HP x 3 U x 220 mm

Weight: 1170 g

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